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GB 2125651 A GB 2125649 A GB 1265878 A
US 5036347 A US 4387974 A

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INT CL^5 A61B 3/113

(54) Visual axis detection

(57) In order to determine the direction of the gaze of the user of an automatic focusing camera, the user's eyeball is illuminated by LEDs 4a, 4b. The eyeball and resultant reflections are viewed by CCD array 9 acting as an image sensor. In order to overcome problems arising from ambient light, during a first accumulation period in which the LEDs 4a, 4b are illuminated the output of array 9 is stored in RAM 21; during a second period, the LEDs 4a, 4b are not illuminated, and the resultant signal is subtracted from the stored signal; this difference signal is then used to determine the user's direction of gaze; a suitable autofocus sensor can then be selected.

FIG. 1

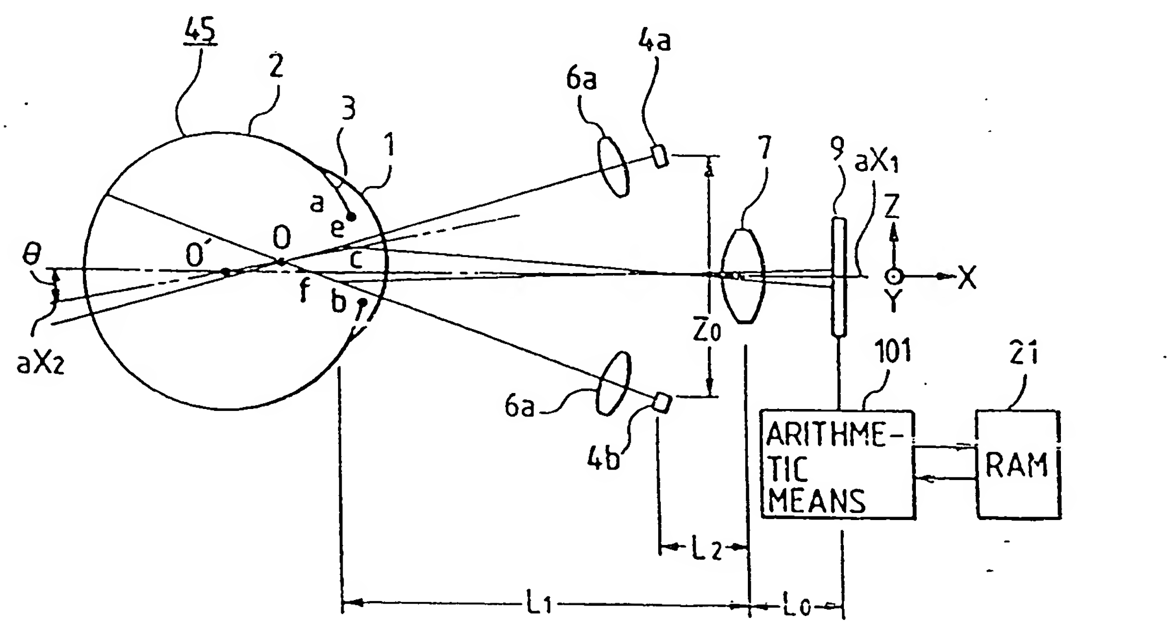

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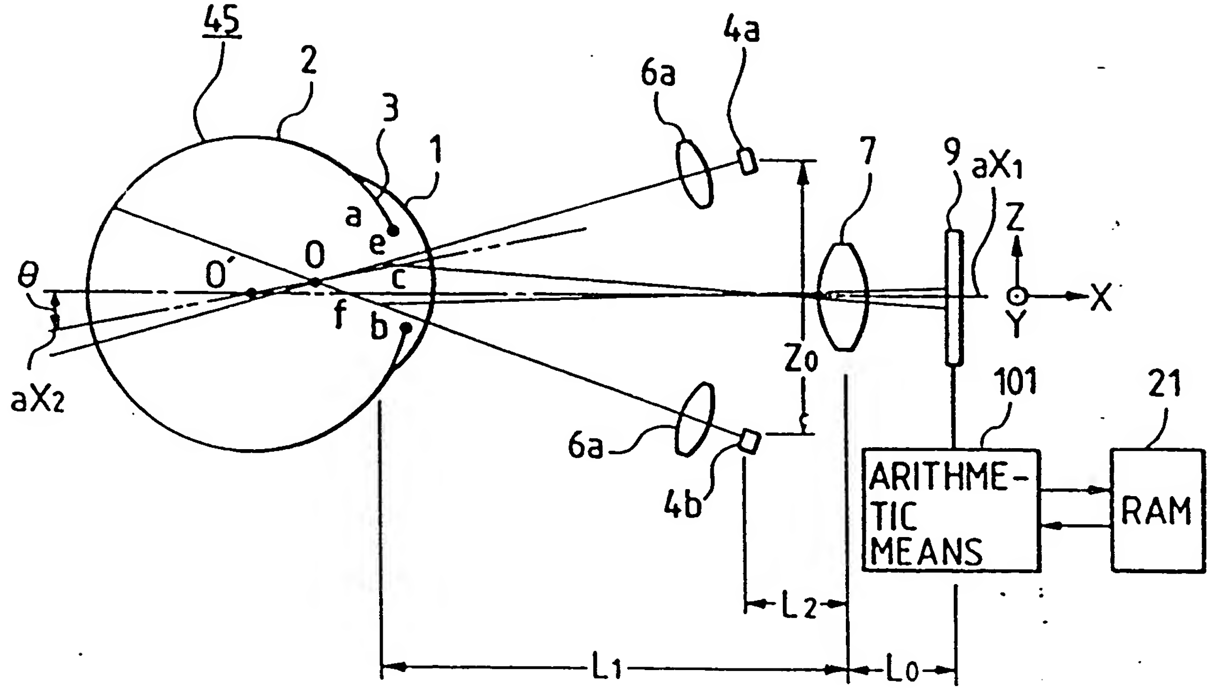
FIG. 1


45
2
3
1
a
e
O
O'
c
f
b
θ
aX2
6a
4a
7
9
aX1
Z
X
Y
Z0
6a
4b
101
21
ARITHMETIC MEANS
RAM
L2
L1
L0

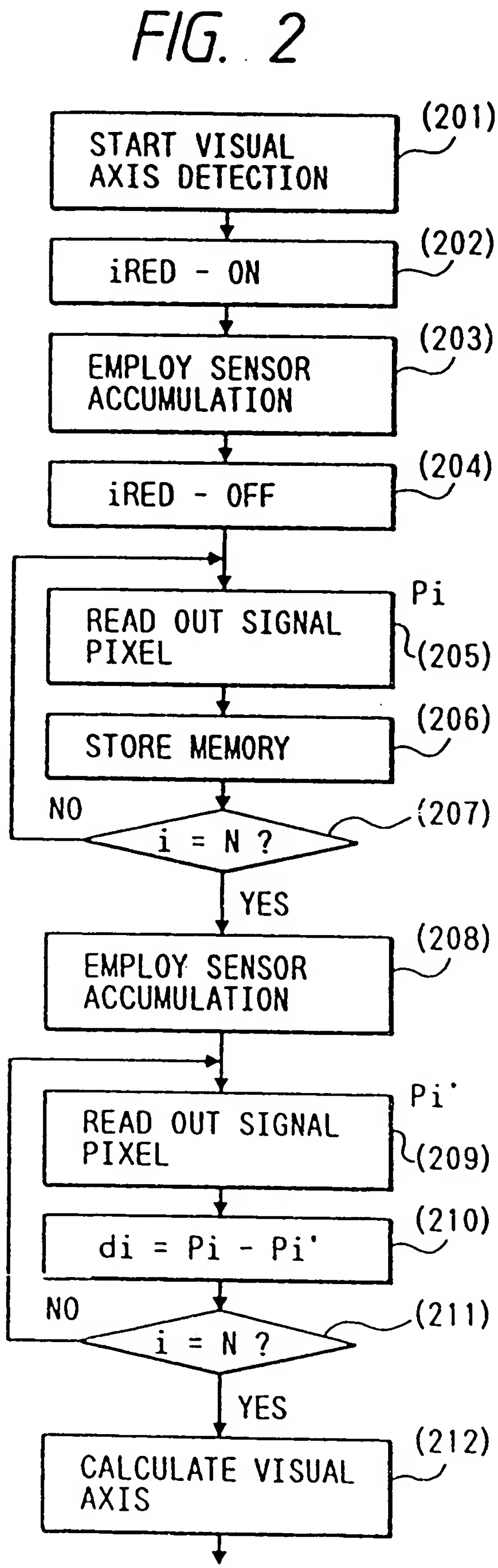


FIG. 2
START VISUAL AXIS DETECTION
(201)
iRED - ON
(202)
EMPLOY SENSOR ACCUMULATION
(203)
iRED - OFF
(204)
READ OUT SIGNAL PIXEL
Pi
(205)
STORE MEMORY
(206)
NO
i = N ?
(207)
YES
EMPLOY SENSOR ACCUMULATION
(208)
READ OUT SIGNAL PIXEL
Pi'
(209)
di = Pi - Pi'
(210)
NO
i = N ?
(211)
YES
CALCULATE VISUAL AXIS
(212)

FIG. 3

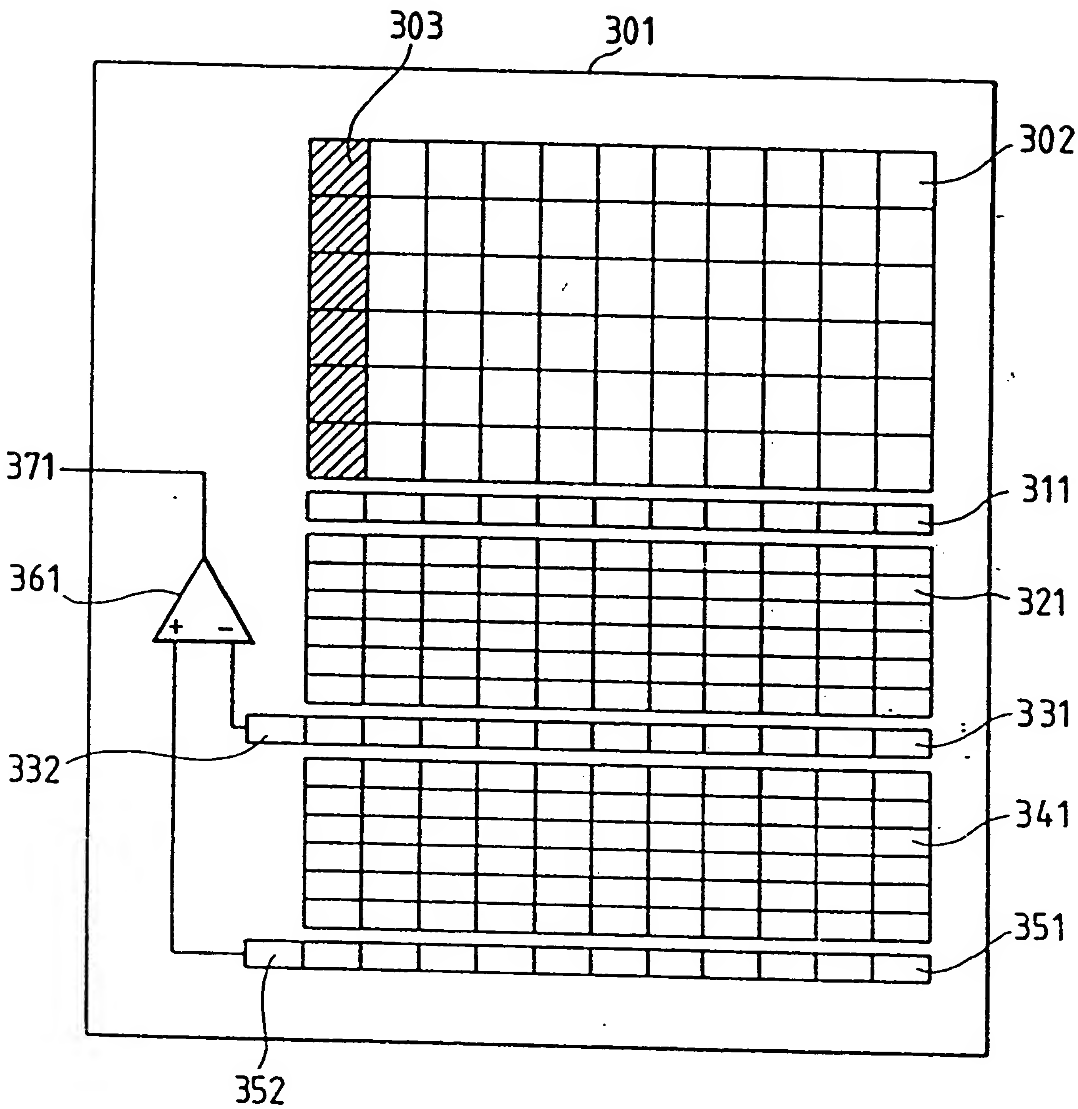


FIG. 4

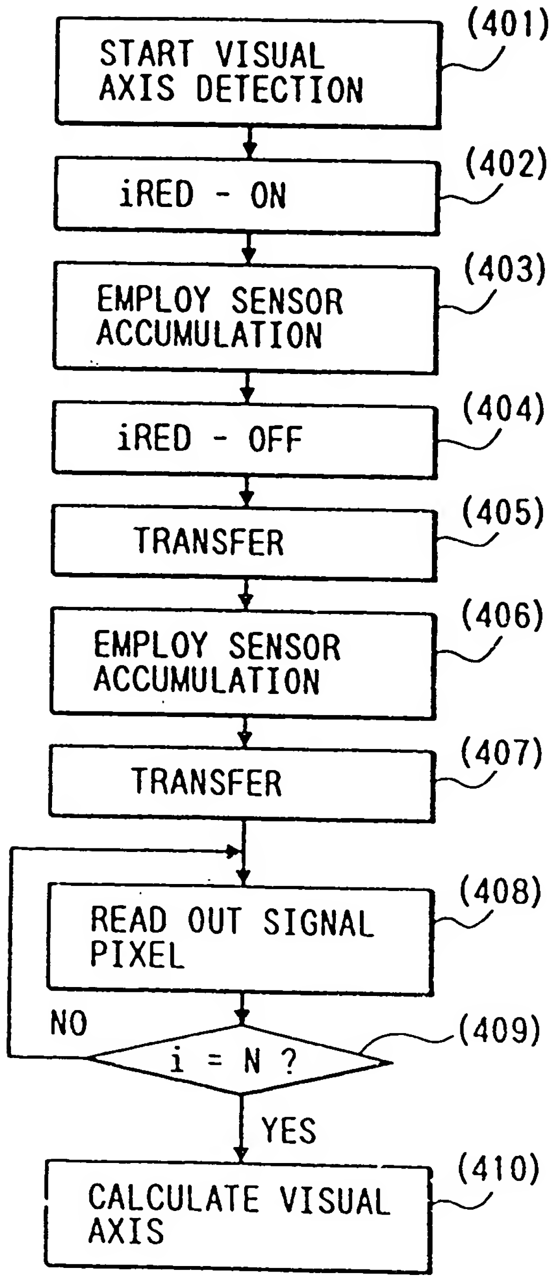

START VISUAL AXIS DETECTION
(401)
iRED - ON
(402)
EMPLOY SENSOR ACCUMULATION
(403)
iRED - OFF
(404)
TRANSFER
(405)
EMPLOY SENSOR ACCUMULATION
(406)
TRANSFER
(407)
READ OUT SIGNAL PIXEL
(408)
NO
i = N ?
(409)
YES
CALCULATE VISUAL AXIS
(410)

FIG. 5 PRIOR ART

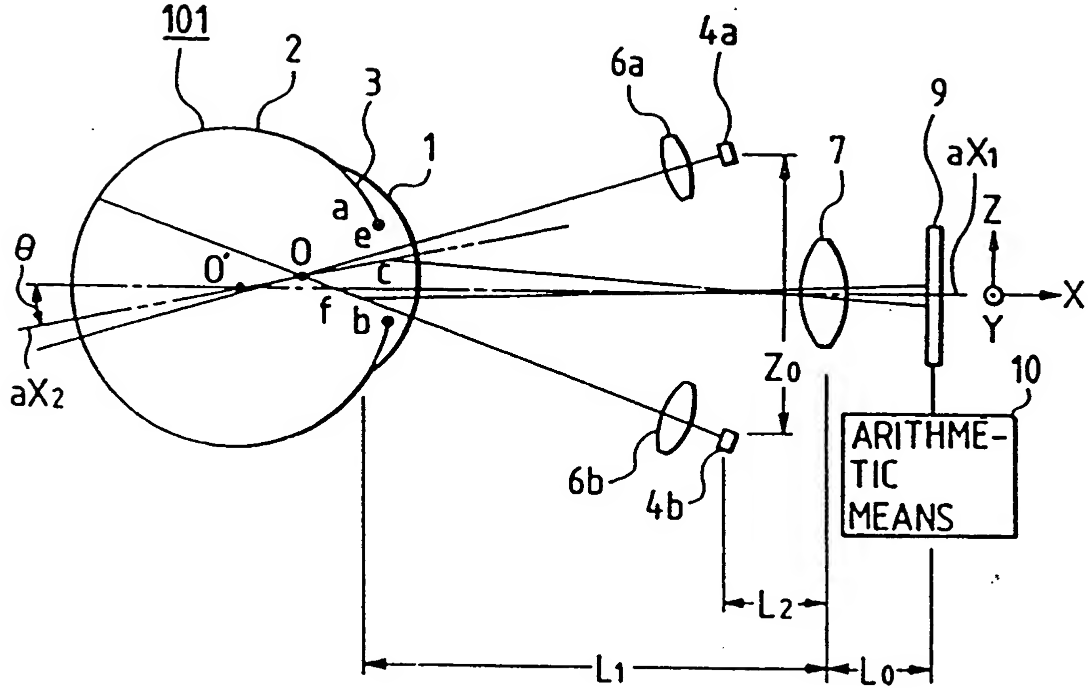


FIG. 6

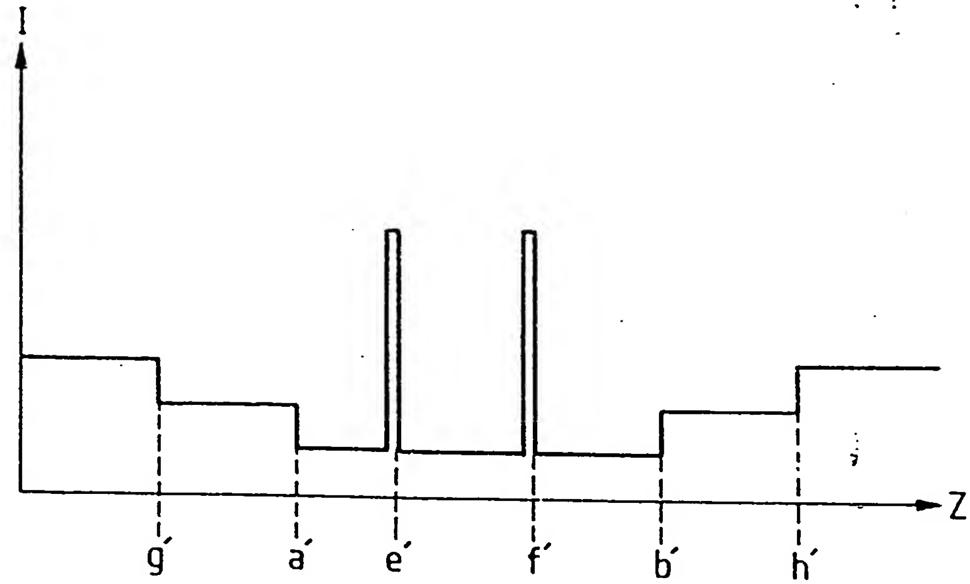


FIG. 7

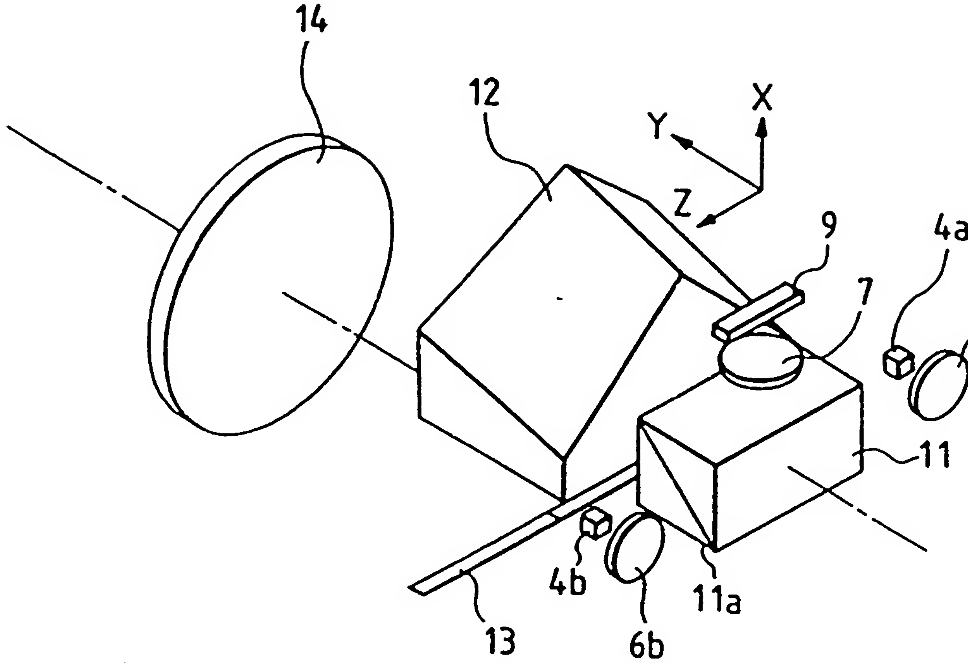


FIG. 8

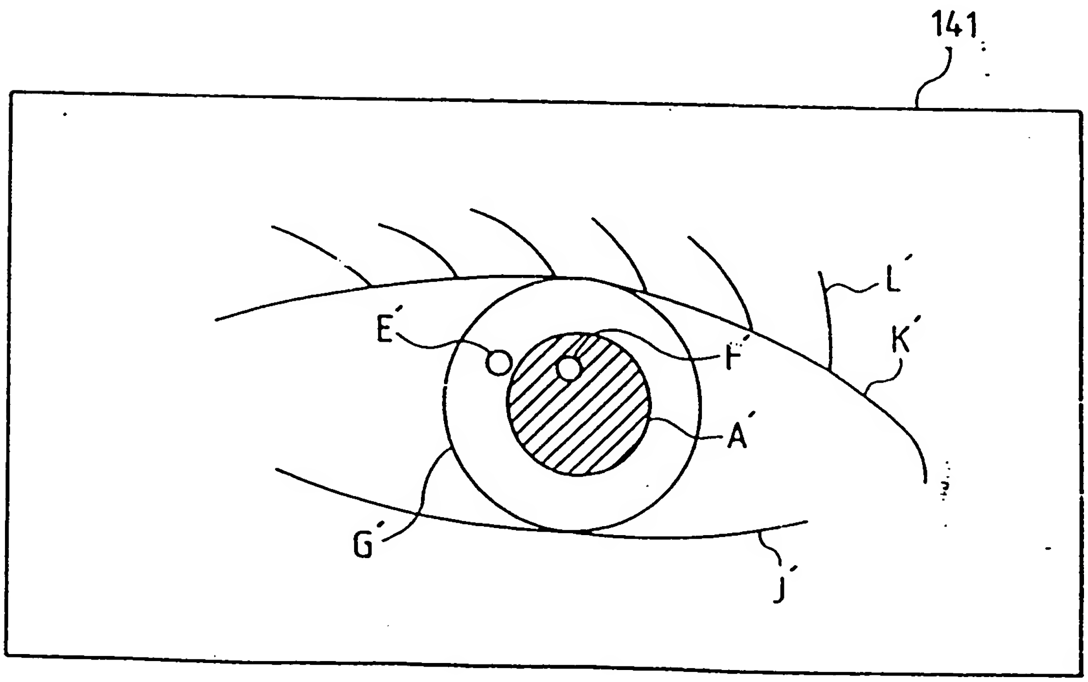


FIG. 9

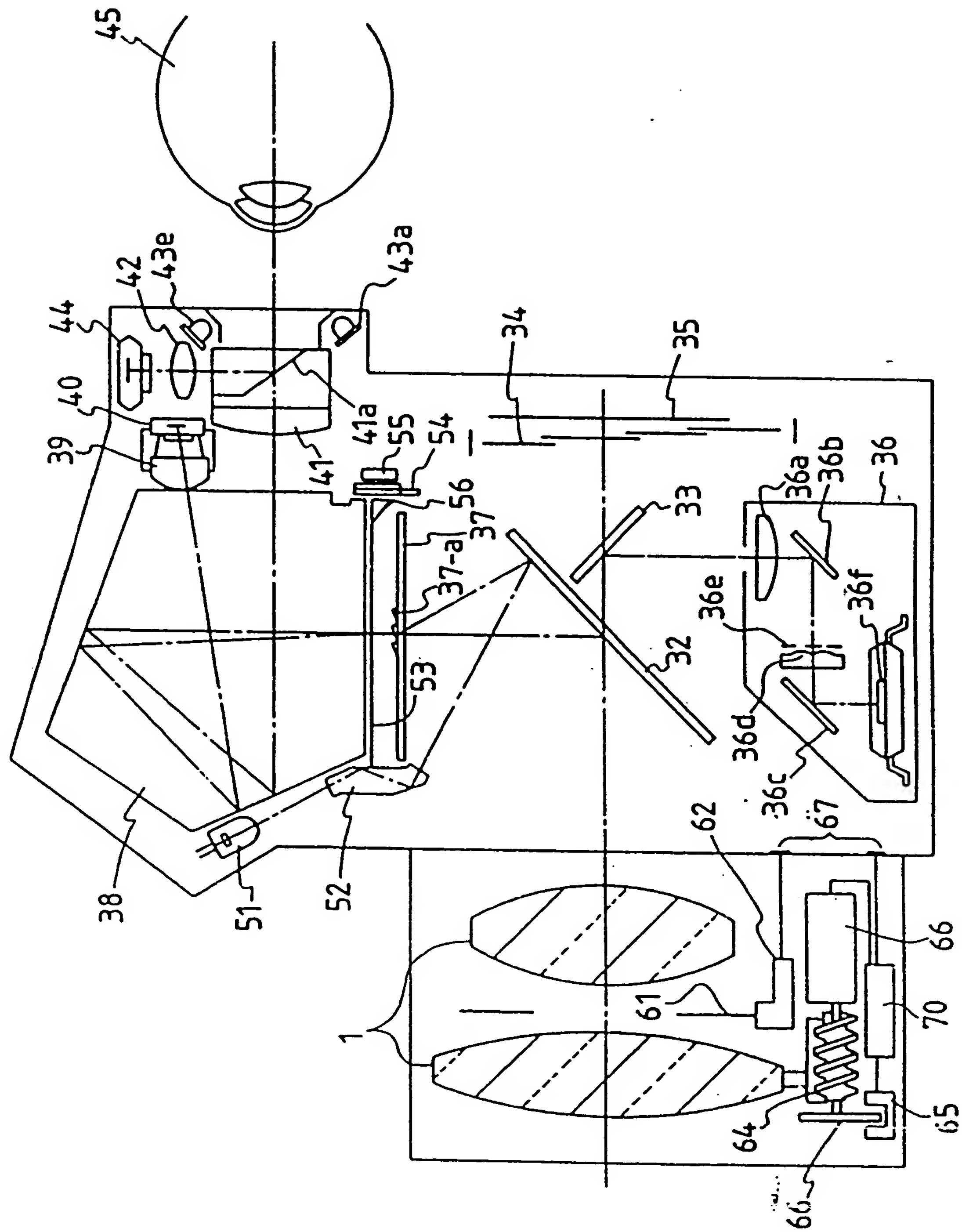
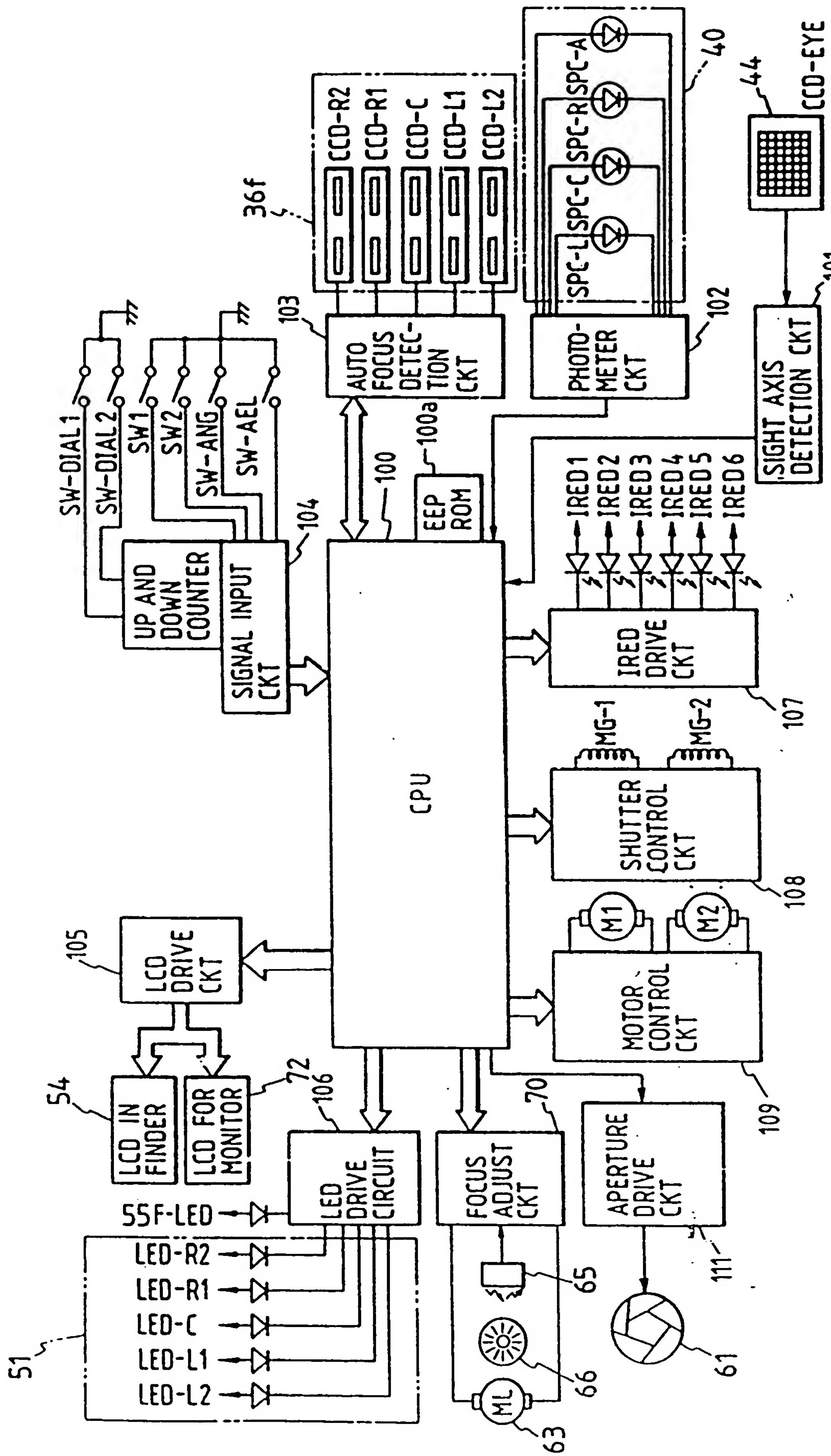

45
44
42
43e
43a
40
39
41a
55
54
41
56
37
37-a
34
35
33
36a
36b
36
36e
36f
32
53
36d
36c
62
67
38
51
52
66
61
70
1
64
65

FIG. 10


CPU
100
EEP ROM
100a
AUTO FOCUS DETECTION CKT
103
36f
CCD-R2
CCD-R1
CCD-C
CCD-L1
CCD-L2
PHOTO-METER CKT
102
SPC-L
SPC-C
SPC-R
SPC-A
40
SIGHT AXIS DETECTION CKT
101
44
CCD-EYE
UP AND DOWN COUNTER
SIGNAL INPUT CKT
104
SW-DIAL1
SW-DIAL2
SW1
SW2
SW-ANG
SW-AEL
IRED DRIVE CKT
107
IRED1
IRED2
IRED3
IRED4
IRED5
IRED6
SHUTTER CONTROL CKT
108
MG-1
MG-2
MOTOR CONTROL CKT
109
M1
M2
LCD DRIVE CKT
105
LCD IN FINDER
54
LCD FOR MONITOR
72
LED DRIVE CIRCUIT
106
55F-LED
LED-R2
LED-R1
LED-C
LED-L1
LED-L2
51
FOCUS ADJUST CKT
70
65
66
ML
63
APERTURE DRIVE CKT
111
61

VISUAL AXIS DETECTION APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a visual axis detection apparatus, and especially to a visual axis detection apparatus which detects an axis in an observation point direction of a viewer (photographer) or a so-called visual axis when the viewer observes an observation plane (imaging plate) on which an object image is formed by a photographing system in an optical system such as a camera, by utilizing a reflected image (eyeball image) formed when an eyeball of the viewer is illuminated with an infrared ray.

Related Background Art

Various visual axis detection apparatuses for detecting the visual axis to detect a position on a view plane which the viewer (examined person) views have been proposed.

For example, in Japanese Laid-Open Patent Application No. 2-264632, an infrared light beam from a light source is projected to an anterior eye in an eye to be examined and an axis of vision (observation point) is determined by utilizing a cornea reflected image on the basis of a reflected light from a cornea and a focus-imaging point on a pupil.

In a camera disclosed in Japanese Laid-Open

Patent Application No. 61-61135, a direction of metering by a focus detection apparatus is mechanically controlled on the basis of an output signal from a visual axis detection means to adjust a focal point state of a photographing system.

Fig. 5 is a schematic view of a visual axis detection apparatus proposed in Japanese Laid-Open Patent Application No. 2-264632, Fig. 6 is an explanation view for an output signal from one line of an image sensor of Fig. 5, and Fig. 7 is a perspective view of a portion of a finder system when the visual axis detection apparatus of Fig. 5 is applied to a single eye reflex camera.

Numeral 101 denotes an eyeball of an examined person (observer), numeral 1 denotes a cornea of the eyeball of the examined one, numeral 2 denotes a sclera, and numeral 3 denotes an iris. O' denotes a center of rotation of the eyeball 101, O denotes a center of curvature of the cornea 1, a and b denote ends of the iris 3, and e and f denote positions where cornea reflected images are formed owing to light sources 4a and 4b to be described hereinafter. Numeral 4a and 4b denote light sources which may be light emitting diodes or the like for emitting infrared rays which are unpleasant for the examined one. The light source 4a (4b) is arranged closer to a projection lens 6a (6b) than to a focal plane of the projection lens

6a (6b). The projection lenses 6a and 6b are applied for widely illuminating the cornea 1 defining a light beam from the light sources 4a and 4b as diverged light beam.

The light source 4a lies on an optical axis of the projection lens 6a and the light source 4b lies on an optical axis of the projection lens 6b, and they are arranged symmetrically along a z-axis direction with respect to an optical axis aX_1.

Numeral 7 denotes a light receiving lens which forms the cornea reflected images e and f formed near the cornea 1 and the ends a and b of the iris 3 on an image sensor plane 9. Numeral 10 denotes an arithmetic means which calculates the visual axis of the examined one by using the output signal from the image sensor 9. aX_1 denotes an optical axis of the light receiving lens 7 and it matching to an X axis in Fig. 5. aX_2 denotes an optical axis of the eyeball which makes an angle θ to the X axis.

In this example, the infrared ray emitted from the light source 4a (4b) passes through the projection lens 6a (6b) and thereafter widely illuminates the cornea 1 of the eyeball 101 with diverging state. The infrared ray which passes through the cornea 1 illuminates the iris 3.

The cornea reflected images e and f based on the light beam reflected by the surface of the cornea

1 of the infrared rays for illuminating the eyeball are reformed at points e' and f' on the image sensor 9 through the light receiving lens 7. In Figs. 5 and 6, e' and f' denote projection images of the cornea reflected image (virtual images) e and f formed by a set of light sources 4a and 4b. Centers of the projection images e' and f' substantially match to the projection point on the image sensor 9 of the cornea reflected image formed when the illumination means is arranged on the optical axis aX_1.

The infrared ray which is diffusion-reflected by the surface of the iris 3 is directed to the image sensor 9 through the light receiving lens 7 to form the iris image.

On the other hand, the infrared ray transmitted through the pupil of the eyeball illuminates a retina has the wavelength of the infrared range and the illuminated area is an area of a low view cell density which is apart from a center area, so that the examined one cannot recognize the light sources 4a and 4b.

An ordinate in Fig. 6 represents an output I along the z-axis direction of the image sensor 9. Since most of the infrared ray transmitted through the pupil are not reflected back, there is no difference of the output at the boundary between the pupil and the iris 3. As a result, the iris images a' and b' at the ends of the iris can be detected.

When an area sensor having a two-dimensional photo-sensor array is used as the image sensor 9 of Fig. 6, two-dimensional light distribution information of the reflected image (eyeball image) is obtained from the front eye as shown in Fig. 8.

In Fig. 8, numeral 141 denotes a light receiving area of the image sensors, E' and F' denote cornea reflected images of the light sources 4a and 4b, A' denotes a boundary between the iris and the pupil, and G' denotes a boundary between the sclera 2 and the cornea 1. Since the reflectivities of the sclera 1 and the iris 3 are not substantially different from each other in the infrared range, the boundary G' can not be clearly discriminated by a naked eye. J' denotes an image of a lower eyelid, K' denotes an image of an upper eyelid and L' denotes an image of eyelashes.

In order to detect the direction of the visual axis from the eyeball image of the front eye, it has been known to calculate a relative relation between the cornea reflected images E' and F' (or an intermediate image of E' and F') and the position of the center of pupil. Various methods for determining the center of pupil have been known. For example, an output of one particular line of the image sensor is sampled to calculate a center point of the pupil edge positions a' and b' of Fig. 6. Alternatively, the output information of the area sensor may be used to sample

a number of pupil edge points and thereafter determine the center point by a least square approximation.

An optical equipment having a finder system such as a still camera or a video camera is frequently used in out-of-door. When such an optical equipment is used in out-of-door, the eyeball of the photographer is illuminated by an external ray. Thus, an image forming light beam received by the image sensor 9 includes not only the image of the front eye illuminated with the light sources 4a and 4b but also a complex image affected by disturbance by the external ray.

The most problem external ray is a direct light incident on the front eye from the sun. An energy of the sunlight is very strong and includes a plenty of the same spectrum components as those of the spectrums emitted by the light sources 4a and 4b. Accordingly, it is difficult to fully eliminate the external ray by spectrum means such as a visible ray cut filter.

When the front eye is illuminated by the sunlight, a variety of disturbances are generated in the image. When the amount of external ray is largely illuminated, the external ray component is stronger than infrared component. As a result, a pattern (eyeball image) cannot be substantially discriminated. When the external ray exists, a brightness in the pupil which should be at a lowest brightness level of

luminescence (between a' and b' in Fig. 6) becomes higher or declined so that the detection of the pupil edges and hence the decision of the center of the pupil cannot be correctly determined.

When the neighborhood of the boundary of the sclera and the iris is strongly illuminated, a obscure edge which inherently seems unclear rises to the surface or becomes declined therein, so that the pupil edges are misdetected. When the eyelashes grow downward, they are illuminated by the external ray, so that they may be misdetected as the pupil edge. Since the eyelashes extend out of the face in contrast to the eyeball, they are easily subject to the illumination by the external ray.

Such a misdetection occurs not only for the pupil edge but also for the cornea reflected images e and f of the light sources 4a and 4b. When the ends of the eyelashes are directly illuminated by the sunlight, they become strong brilliant points, which are misdetected as the cornea reflected images. When eyeglasses are put, dusts deposited on the eyeglasses may be highlighted.

Besides the sunlight, a down light having high luminescence and various artificial light sources are also utilized as the external ray. When eyeglasses are put, a distance between the eyepiece portion in the finder system and the eyeball generally becomes

apart, so that the external ray easily enters into the eye. Further, the reflection coming from the lens surfaces of the eyeglasses is adversely affected.

When the visual axis is to be detected by using the image signal from the image sensor, an accumulation-type image sensor is frequently used in view of a requirement for the sensitivity. As a result, there has been a problem that a DC noise elimination by an AC coupling or a period detection system which is usually used in a single sensor cell cannot be used.

The present invention is concerned with providing a visual axis detection apparatus for detecting an eyeball image by using accumulation-type image pickup means which reduces an affect by a noise due to an external ray and detects the visual axis of the eyeball of the photographer (the examined person) who looks into a finder, by properly setting an accumulation method of the eyeball image (image information) by the image pickup means and a processing method of the image information based on the eyeball image from the image pickup means.

In the visual axis detection apparatus of the present invention, the eyeball of the examined person is illuminated by a light beam coming from illumination means, an eyeball image based on a reflected light

from the eyeball is formed on a surface in accumulation-type image pickup means, an image signal from the image pickup means is stored in memory means, and a visual axis of the examined person is calculated by utilizing the image signal stored in the memory means. The image pickup means has first and second accumulation periods and the memory means stores the image signal of the eyeball generated in one of the two accumulation periods and the illumination means emits a light in one of the two accumulation periods. A difference signal between the image signal from the image pickup means generated in the first accumulation period and the image signal generated in the second accumulation period is determined by differential signal generation means and the visual axis of the examined person is detected based on the signal from the differential signal generation means.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a main schematic view of the embodiment 1;

Fig. 2 shows a flowchart of the embodiment 1;

Fig. 3 shows a main schematic view of an image sensor of the embodiment 2;

Fig. 4 shows a flowchart of the embodiment 2;

Fig. 5 shows a main schematic view of a conventional visual axis detection apparatus;

Fig. 6 shows an explanation view of output signal from the image sensor in Fig. 5;

Fig. 7 shows a main schematic view when the visual axis detection apparatus is applied to a single reflex camera;

Fig. 8 shows an explanation view of an eyeball image formed on an area sensor;

Fig. 9 shows a view when the visual detection apparatus is mounted into a single reflex camera; and

Fig. 10 shows a block diagram for explaining how the apparatus in Fig. 9 is controlled.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows a schematic diagram of Embodiment 1 of the present invention and Fig. 2 shows a flow chart for explaining the visual axis detection in the Embodiment 1.

In the present embodiment, in contrast to the conventional visual detection apparatus of Fig. 5, a photo-electrically converted signal from the image sensor 9 which functions as the accumulation-type image

pickup means is processed by arithmetic means 101, and a RAM (memory) 21 for storing the data from the arithmetic means 101 is further provided. Specifically, the visual axis operation method is improved in the arithmetic means 101 by using the data stored in the RAM 21 to eliminate the adverse affect by the external ray.

The elements of the present embodiment are now explained in sequence although it may be partially duplicate to the description for Fig. 5.

In Fig. 1, numeral 45 denotes an eyeball of an examined one (viewer), numeral 1 denotes a cornea of the eyeball of the examined one, numeral 2 denotes a sclera and numeral 3 denotes an iris. O' denotes a center of rotation of the eyeball 101, O denotes a center of curvature of the cornea 1, a and b denote ends of the iris 3, and e and f denote positions where cornea reflected images are generated by light sources 4a and 4b to be described hereinafter. Numerals 4a and 4b denote light sources which may be light emitting diodes for emitting infrared rays which are unpleasant by the examined one. The light source 4a (4b) is arranged closer to a projection lens 6a (6b) than to a focal plane of the projection lens 6a (6b). The projection lenses 6a and 6b convert the light beams from the light sources 4a and 4b to diverging lights to widely illuminate on a surface of the cornea 1.

The light source 4a lies on an optical axis of the projection lens 6a while the light source 4b lies on an optical axis of the projection lens 6b and they are arranged symmetrically along a z-axis relative to an optical axis aX_1. The light sources 4a and 4b and the projection lenses 6a and 6b form the illumination means.

Numeral 7 denotes a light receiving lens which focuses the cornea reflected images e and f formed in the vicinity of the cornea 1 and the ends a and b of the iris 3 onto the image sensor 9. The light receiving lens 7 and the image sensor 9 form one of the light receiving means which converts the light from the eye into an electrical signal.

Numeral 101 denotes an arithmetic means which calculates the visual axis of the examined person by using the output signal from the image sensor 9, as will be described hereinafter. The basic detection method therefor is described in Japanese Laid-Open Patent Application No. 4-447127. Numeral 11 denotes a RAM which functions as the memory means which stores data calculated by the arithmetic means 101. aX_1 denotes an optical axis of the light receiving lens 7, which matches with an X-axis. aX_2 denotes an optical axis of the eyeball which makes angle θ to the X axis.

In the present embodiment, the infrared ray emitted from the light source 4a (4b) passes through

the projection lens 6a (6b) and thereafter diverges to widely illuminate the cornea 1 of the eyeball 45. The infrared ray transmitted through the cornea 1 illuminates the iris 3.

The cornea reflected images e and f based on the light beam reflected by the surface of the cornea 1, of the infrared rays illuminating the eyeball are reimaged onto the points e' and f' on the image sensor 9 through the light receiving lens 7. In Figs. 1 and 6, e' and f' denote projection images of the cornea reflected images (virtual images) e and f generated by the set of light sources 4a and 4b. A mid-point of the projection images e' and f' substantially matches to the projection position of the cornea reflected image on the image sensor 9, which is generated when the illumination means is arranged on the optical axis ax_2.

The infrared ray which is diffusion-reflected by the surface of the iris 3 is introduced into the image sensor 9 through the light receiving lens 7 to form the iris image.

On the other hand, the infrared ray transmitted through the pupil of the eyeball illuminates the retina and is absorbed thereby. However since the illuminated area has a low density of viewing cells which is apart from the center, the examined one cannot discriminate the light sources 4a and 4b.

In Fig. 6, an ordinate represents an output I in the z-axis of the image sensor 9. Since most of the infrared rays transmitted through the pupil are not reflected back, there arises a difference in the outputs at the boundary between the pupil and the iris 3 and the iris images a' and b' of the iris edges are detected.

In the present embodiment, the arithmetic means 101 respectively detects coordinates (Za', Zb' and Ze', Zf') of peculiar points (a', b' and e', f') on the eyeball on the image sensor 9 based on a flow chart of Fig. 2, and calculates a rotation angle θ of the eyeball in accordance with a formula:

$$\beta \cdot \overline{OC} \cdot \sin\theta \simeq (Za'+Zb')/2 - (Ze'+Zf')/2$$

where β is a magnification factor of the light receiving optical system ($\simeq L_0/L_1$).

A vision angle of the eyeball is determined from the rotation angle θ to determine of the subject.

In the line of vision detector of the present invention, a distance L_1 between the position at which the cornea reflected image is generated and the light receiving lens 7 satisfies a relation of:

$$(L_1 |Ze'-Zf'|)/L_0 Z_0 \simeq \overline{OC}/(L_1-L_2+\overline{OC})$$

where Z_0 is a spacing in the z-direction of the set of light sources 4a (4b), and L_2 is a spacing in the x direction between the light source 4a (4b) and the light receiving lens 7.

Thus, even if the distance between the line of vision detector and the eyeball changes, the distance L_1 may be calculated from the spacing $|Ze'-Zf'|$ of the two cornea reflected images.

An operation of the visual axis detection apparatus is now explained with reference to the flow chart of Fig. 2.

In a step 201, the detection operation of the visual axis starts. In a step 202, the light sources 4a and 4b are turned on and at the substantial same time, the process proceeds to a step 203 to start the first accumulation operation of the image sensor 9. The accumulation by the image sensor 9 may be controlled by comparing a real time accumulation amount motor signal with a predetermined reference, or by time control by hardware or software timer.

The process proceeds to a step 204 at the substantial end time of the first accumulation of the image sensor to turn off the light sources 4a and 4b. The photo-electric conversion signals of the image sensor 9 are sequentially read through a loop of steps 205-207 and the A/D converted electrical signals Pi of the cells are stored in the memory (RAM) 21. Where the image sensor 9 itself does not have a memory function, the image sensor 9 may senses the light and error-move during reading the signals. Accordingly, the loop is designed to be completed in a sufficiently

short time in comparison with the accumulation time.

Where the image sensor 9 includes an analog memory function, the signal charges may be temporarily shifted to the non-photosensitive memory and sequentially read into digital system at a low speed. The memory function of the present embodiment may be implemented as a CCD channel or a capacitor array.

When the reading and storing of all of the required pixels are completed, the process proceeds to a step 208 to conduct the second accumulation operation. The accumulation time of the second accumulation is substantially same as the accumulation time of the first accumulation done in the step 203.

In the second accumulation operation, the light sources 4a and 4b are not turned on and the front eye image is sampled by only the external ray illumination to cancel the external ray components. In the present embodiment, the accumulation time may be reduced to one half and the read gain may be doubled in order to reduce the accumulation time while keeping the apparent signal quantity.

When the second accumulation operation is finished, the photoelectric conversion signals of the image sensor are sequentially read through a loop of steps 209-211.

Then the arithmetic means 10 reads the signals Pi of the same pixels produced in the first accumulation,

calculates differences di between the signals Pi and the current signals Pi' and restores the result in the memory 21.

In the present embodiment, the arithmetic means 101 also includes a function of differential signal generation means for determining the differential signal Pi'. This operation is carried out for all the pixels so that the memory 21 has an image signal based on the eyeball image which substantially eliminates the contribution of the external ray due to the sunlight or the like. In the present embodiment, the direction of the visual axis is calculated in a step 212 based on the above image signal so that the malfunction is prevented and the highly accurate detection of the visual axis is attained.

Fig. 3 shows a schematic view of an image sensor (a sensor chip) 301 in Embodiment 2 of the present invention, and Fig. 4 shows a flow chart of the operation of the present embodiment. Other elements of the present embodiments are substantially identical to those of the Embodiment 1.

In Fig. 3, numeral 301 denotes a sensor chip having a well-known self-scanning system and a power supply and the like, and it is shown as a functional block in Fig. 3 for simplification.

The sensor chip 301 is provided at the position of the image sensor 9 in Fig. 1. Numeral 302 denotes

a photo-sensing block which is a CCD sensor having M x N areas. Fig. 3 shows a frame-transfer-type system which shares the photo-sensing unit with a transfer unit although the same function may be attained by an interline-type system. A masked column 303 is provided at a left end of the photo-sensitive area. It is a monitor pixel to detect a dark signal level. A transfer buffer 311, a first memory 321, a transfer buffer/horizontal read register 331, a second memory unit 341, a transfer buffer/horizontal read register 351, and a differential amplifier 361 are provided in sequence. The elements other than the photo-sensitive area are fully shielded from the light by an aluminum film or the like.

An operation of the present embodiment is now explained with reference to a flow chart of Fig. 4.

In a step 401, the visual axis detection operation starts. In a step 402, the light sources 4a and 4b are turned on. At the substantially same time, the first accumulation operation of the image sensor 301 is started in a step 403, and after employing the accumulation to a predetermined monitor level or after a predetermined time, the accumulation is terminated.

In a step 404, the light sources 4a and 4b are turned off, and in a step 405, the transfer operation is conducted. In the transfer operation,

the signal charges accumulated in the photo-sensing unit 302 of the image sensor 301 are transferred to the memory unit 321 through the transfer buffer 311.

The transfer method is well-known. In the illustrated frame-transfer-type system, the signal charges of the pixels are transferred downward one line per one clock. The entire image is transferred to the memory unit 321 by (N+1) clocks including those for the buffer. It is necessary that the time required for the transfer is sufficiently shorter than the accumulation time. In the present embodiment, the transfer rate of the CCD channel is determined by the hardware and it is sufficiently high, so that any problem does not arise.

When the transfer is over, the process proceeds to a step 406 to conduct the second accumulation operation. Since the charges of the photo-sensing unit are evacuated by the previous transfer operation, a reset operation is not necessary but it may be conducted prior to the second accumulation if the circuit is designed to conduct the reset operation.

In the second accumulation, the light sources 4a and 4b are not turned on and the signal charges by only the external ray are accumulated. After completing the accumulation, the process proceeds to a step 407 to conduct the transfer.

In the transfer operation, the signal charges

accumulated in the photo-sensing unit 302 are transferred to the memory unit 321 and at the same time the signal charges stored in the memory 321 by the first accumulation are transferred to another memory unit 341. Since they are simultaneously and parallelly proceeded, the signal charges by the two accumulations are not mixed and the transfers are completed by (N+1) clocks. Finally, the signal charges by the first accumulation are stored in the memory 341 and the signal charges by the second accumulation are stored in the memory 321.

In the next sequence, the signal is read outwardly through a loop of steps 408-409. This sequence may be lower at speed than the transfer in the sensor chip owing to an external radial circuit but the signal may be read without regard to the sensing by the sensor because the signal charges have been transferred to the light-shielded memory unit.

The signal charges stored in the memory units (321 and 341) are sequentially transferred, pixel by pixel, to the charge-voltage converters 332 and 352 by the function of the horizontal line read registers 331 and 351, and the signal voltages are applied to the input terminals of the differential amplifier 361. Since the both horizontal registers 331 and 351 are operated by one clock simultaneously, the signals of the same pixel of the photo-sensing unit 302 produced

in the first and second accumulations are simultaneously applied to the positive and negative inputs of the differential amplifier 361. As a result, the image signal which the external ray components is subtracted therefrom appears at the output terminal 371. When it is done for all pixels, the process proceeds to a step 410 to calculate the visual axis. In the present embodiment, the affection caused by the external ray is eliminated in such a manner to attain a highly reliable signal.

In the present embodiment, a capacitor array may be also used to eliminate the external ray in the sensor chip. An image sensor which temporarily stores the photo-excited image signal charges in the capacitor array through a current amplifier element such as a transistor and thereafter sequentially read them out has been known, and hence the elimination of the external ray which is functionally equivalent to the CCD arrangement described above may be attained.

Only one set of the memory unit may be provided for the first accumulation signal and the second accumulation signal may be subtracted on the chip and the result is output. Alternatively, it may be re-stored in the memory. The significance of the present invention is not limited by the specific details of the implementation.

Fig. 9 shows a schematic diagram of an

embodiment in which the line of vision detector of the present invention is applied to a single reflex camera.

In Fig. 9, numeral 31 denotes a photographing lens which comprises two lenses for the sake of convenience although it actually comprises more lenses. Numeral 32 denotes a main mirror which is skewed into a photographing path or retracted therefrom depending on a view state of an object by a finder system and a photographing state of an object image. Numeral 33 denotes a sub-mirror which reflects a light beam transmitted through the main mirror 32 to a focal point detection apparatus 39 at a bottom of a camera body to be described later.

Numeral 34 denotes a shutter and numeral 35 denotes a photo-sensing member such as a silver salt film, CCD or MOS or the like solid state image pickup device, or an image pickup tube such as a videcon.

Numeral 36 denotes a focal point detection apparatus which comprises a field lens 36a arranged near a focusing plane, reflection mirrors 36b and 36c, a secondary image forming lens 36d, a diaphragm 36e and a line sensor 36f and the like including a plurality of CCD's.

The focal point detection apparatus 36 in the present embodiment uses a well-known phase difference system. Numeral 37 denotes an imaging plate arranged

on an anticipated focusing plane of the photographing lens 31, numeral 38 denotes a pentadaha prism for altering a finder optical path, and numerals 39 and 40 denotes an image forming lens and a photometering sensor, respectively, for measuring an brightness of the object in the view field. The focusing lens 39 is related in conjugate with the imaging plate 37 and the photometering sensor 40 through a reflection optical path in the pentadaha prism 38.

An eyepiece lens 41 having an optical splitter 41a is arranged behind an exit plane of the pentadaha prism 38 and it is used for the observation of the imaging plate 37 by the eye 45 of the photographer. The optical splitter 41a comprises a dichroic mirror which transmits a visible ray and reflects an infrared ray.

Numeral 42 denotes a light receiving lens and numeral 44 denotes an image sensor having two-dimensionally arranged photo-electric element array such as CCD's as explained above, which is arranged in conjugate with the vicinity of the pupil of the eye 45 of the photographer which is at a predetermined position with respect to the light receiving lens 42 (corresponding to 9 in Fig. 1). Numeral 43 denotes an infrared ray emitting diode which functions as the light source (corresponding to 4 in Fig. 1).

Numeral 51 denotes a high intensity superimposing

LED which can be recognized even for a bright object. The emitted light is reflected by the main mirror 32 through the projection lens 52 and vertically deflected by a fine prism array 37a arranged at a display area of the imaging plate 37 and reaches the eye 45 of the photographer through the penta prism 38 and the eyepiece lens 41.

The fine prism arrays 37a are formed in frame shape at a plurality of points (metering points) corresponding to the focus detection area of the imaging plate 37, and they are illuminated by five corresponding superimposing LED's 51 (which are defined as LED-L1, LED-L2, LED-C, LED-R1 and LED-R2).

Numeral 53 denotes a view field mask which forms a finder view field and numeral 54 denotes an LCD in the finder for displaying photographing information outside of the finder view field. It is illuminated by an illumination LED (F-LED) 55.

The light transmitted through the LCD 54 is introduced into the finder view field by a triangular prism 56 and it is displayed outside of the finder view field so that the photographer may recognize the photographing information.

Numeral 61 denotes a diaphragm provided in the photographing lens 31, numeral 64 denotes an aperture driver including an aperture drive circuit 70 to be described later, numeral 63 denotes a lens

drive motor, numeral 64 denotes a lens drive member including drive gears and the like, and numeral 65 denotes a photo-coupler which detects the rotation of a pulse disk 66 coupled to the lens drive member 64 and transmits it to the lens focal point adjusting circuit 70, which drives the lens drive motor based on the information from the photo-coupler 65 and the lens driving amount information from the camera to drive the photographing lens 31 into an in-focus position. Numeral 67 denotes a well-known mount contact point which is an interface to the camera and the lens.

Fig. 10 shows an electric circuit built in the camera of the present embodiment, and the like elements to those of Fig. 9 are designated by the like numerals.

Connected to a central processing unit (CPU) 100 of a microcomputer built in the camera body are a visual axis detection circuit 101, a photometer circuit 102, an automatic focal point detection circuit 103, a signal input circuit 104, an LCD drive circuit 105, an LED drive circuit 106, an IRED drive circuit 107, a shutter control circuit 108, and a motor control circuit 109. Signals are exchanged with the focus drive circuit 70 and the aperture drive circuit 111 arranged in the photographing lens through the mount contact point 67 shown in Fig. 9.

An EEPROM 100a associated with the CPU 100

has a visual axis correction data memory function for correcting a individual differential error of the visual axis.

As described above, the visual axis detection circuit 101 A/D-converts the output of the eyeball image from the image sensor (CCD-EYE) based on the difference between the output in the illuminated state and the output in the non-illuminated state and sends the image information to the CPU 100, which samples each of characteristic points of the eyeball image necessary for the detection of the visual axis in accordance with a predetermined algorithm and calculates the visual axis of the photographer based on the positions of the characteristic points.

The photometer circuit 102 amplifies the output from the photometering sensor 40, logarithmically compresses it, A/D-converts it, and sends the output to the CPU 100 as the luminescence information of each sensor. In the present embodiment, the photometering circuit 40 has photo-diodes including SPC-L, SPC-C, SPC-R and SPC-A for photometering four areas.

The line sensor 36 of Fig. 10 is a well-known CCD line sensor including five line sensors CCD-L2, CCD-L1, CCD-C, CCD-R1 and CCD-R2 corresponding to the five metering points in the image.

The automatic focus detection circuit (focal point detection circuit) 103 A/D-converts the voltage

obtained from the line sensor 36f and sends it to the CPU 100. SW-1 denotes a switch which is turned on by a first stroke of a release button to start the photometering, the auto-focusing and the detection of the visual axis, SW-2 denotes a release switch which is turned on by a second stroke of the release button, SW-AEL denotes an AE lock switch which is turned on by depressing an AE lock button, and SW-DIAL1 and SW-DIAL2 denote dial switches provided in an electronic dial (not shown) which are connected to an up/down counter of the signal input circuit 104 to count on rotation clicks of the electronic dial.

Numeral 105 denotes a well-known LCD drive circuit for driving the liquid crystal display element LCD. It can display the aperture value, the shutter speed and the preset photographing mode on the monitor LCD 72 and the LCD 54 in the finder simultaneously in accordance with the signal from the CPU 100. The LED drive circuit 106 turns on and off the illumination LED (F-LED) 55 and the superimposing LED 51. The IRED drive circuit 107 selectively turns on the infrared ray emitting diodes (IRED1-6) according to surrounding states.

The shutter control circuit 108 controls a magnet MG-1, which, when actuated, drives a leading curtain, and a magnet MG-2 which drives a trailing curtain, to impart a predetermined amount of light

exposure to a photosensitive member. The motor control circuit 109 controls a motor M1 which winds up and rewinds a film, and a motor M2 which charges the main mirror 32 and the shutter 34. The shutter control circuit 108 and the motor control circuit 109 carry out a series of camera release sequence.

In detecting the visual axis, the eyeball of the subject is illuminated by the light beam from the illumination means 43, the eyeball image is formed on the accumulation type image pickup means 44 based on the reflected light from the eyeball, the image signal from the image pickup means is stored in the memory means 21 (RAM) (Fig. 1), and the visual axis of the subject is calculated by using the image signal stored in the memory means. The image pickup means has first and second accumulation periods, the memory means stores the image signal of the eyeball image generated in one of the two accumulation periods, and the illumination means emits light in only one of the two accumulation periods. A difference signal between the image signal from the image pickup means generated in the first accumulation period and the image signal generated in the second accumulation period is determined by the differential signal generation means and the line of vision of the subject is detected by using the signal from the differential signal generation means. The high luminescence LED 51 illuminates the

point based on the calculated visual axis information and the focus is detected by the focal point detection circuit 103 for the object area corresponding to the illumination point and the photographing lens 31 is driven by the focal point adjusting circuit 70.

In accordance with the present invention, when the eyeball image is to be detected by using the accumulation type image pickup means, the affect by the noise due to the external rays is reduced by properly installing the accumulation method of the eyeball image (image information) by the image pickup means and the processing method of the image information based on the eyeball image from the image pickup means so that the visual axis detection apparatus which can accurately detect the visual axis of the eyeball of the photographer (the examined person) who views the finder.

WHAT IS CLAIMED IS:

1. A visual axis detection apparatus:

conversion means for converting a light from an eye of an examined person to an electrical signal;

illumination means for illuminating said eye;

signal generation means for generating a signal relating to a difference between a first signal of said conversion means when illuminated by said illumination means and a second signal of said conversion means in the absence of illumination; and

detection means for detecting a visual axis on the basis of the signal of said signal generation means.

2. A visual axis detection apparatus according to Claim 1 wherein said illumination means includes memory means for storing the electrical signal of said conversion means in the state where the eye is illuminated by said illumination means, and said signal generation means outputs a signal from which is subtracted an electrical signal of said conversion means in the absence of illumination from the signal stored by said memory means.

3. A visual axis detection apparatus according to Claim 1 wherein said conversion means includes a frame transfer-type solid state image pickup means having a

first memory and a second memory, said first memory stores the electrical signal of said conversion means in the state where the eye is illuminated by said illumination means, and said second memory stores the electrical signal of said conversion means in the absence of illumination.

4. A visual axis detection apparatus comprising:

illumination means for illuminating an eyeball of an examined person;

image pickup means for accumulating a light from the eyeball in a first period and a second period as electrical signals;

control means for making said illumination means illuminate the eyeball for one of said first and second periods to generate a differential signal between an electrical signal of said image pickup means in said one period and an electrical signal of said image pickup means in the other period; and

detection means for detecting a visual axis on the basis of said differential signal.

5. Visual axis detection apparatus comprising means for illuminating a person's eyeball, and means for generating a signal representing the visual axis of the eyeball and utilising a differential signal generated by light reflected from the eyeball when illuminated by said illuminating means but compensated for by a measurement of light reflected from the eyeball when not illuminated by said illumination means.

6. Visual axis detection apparatus substantially as hereinbefore described with reference to and as shown in any one of Figures 1 to 4 of the accompanying drawings.

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Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Documents considered relevant following a search in respect of Claims :-
1-6

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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Category	Identity of document and relevant passages		Relevant to claim(s)
Y	GB 2125651 A	(KODAK) eg. Abstract	1-6
Y	GB 2125649 A	(KODAK) eg. Abstract	1-6
Y	GB 1265878	(PAILLARD SA) Whole document	1, 4, 5
Y	US 5036347	(CANON) Whole document	1-6
X,Y	US 4387974	(USA) eg. Column 5 lines 1-15, 57-65	1, 4, 5 2, 3, 6

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